

L'état de santé des écosystèmes aquatiques.

Vers une méthode intégrative pour une évaluation globale.

The Health Status of Aquatic Ecosystems: Towards an Integrative Method for a global evaluation.

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RÉSUMÉ

Caractériser l'état de santé des milieux aquatiques est nécessaire pour aborder le rapport entre les individus et leur propre santé et la fonctionnalité écologique des hydrosystèmes. Cette confrontation peut s'apparenter à d'autres études investiguant le principe de « Santé unique » adopté par l'ONU pour introduire l'idée d'interdépendances entre la santé humaine, animale et environnementale (Duru, 2017). La recherche collective entre les domaines de la sociologie, de l'environnement et de l'économie permet d'appréhender les liens entre la perception du grand public sur les milieux naturels qu'ils fréquentent et la gestion écologique menée sur ces sites. C'est le cas du projet de recherche pluridisciplinaire Mental'Eau qui explore les corrélations entre l'état écologique de 36 sites (cours d'eau, plans d'eau, canaux...) sélectionnés sur le bassin de la Moselle et du bien-être des individus qui les fréquentent. Dans le cadre de cette étude, un nouvel outil d'évaluation écologique globale des milieux aquatiques a été conçu afin d'apporter un « score de santé » multimétrique aux hydrosystèmes. Cette méthode intègre un panel de critères physico-chimique, biologiques et structuraux relevés à trois échelles emboîtées pour approcher de façon synthétique les différents aspects de l'état de santé des écosystèmes aquatiques.

ABSTRACT

Characterizing the health status of aquatic environments serves as a key tool for assessing the relationship between human health, and the ecological functionalities of aquatic ecosystems. This approach aligns with the 'One Health' principle promoted by the UN, which emphasizes the interconnectedness of human, animal, and environmental health (Duru, 2017). Collaborative research across sociology, environmental science, and economics fields enables a deeper understanding of the links between public perception of natural environments and their ecological management. One example is the interdisciplinary Mental'Eau project, which investigates the correlations between the ecological status of 36 sites (rivers, lakes, canals, etc.) in the Moselle River basin and the well-being of the individuals who frequent them. As part of this study, a new tool for assessing overall aquatic ecosystem health has been developed to provide a multimetric 'health score' for these hydrosystems. This method integrates a range of physico-chemical, biological, and structural criteria, collected at three connected scales, to synthetically approximate different aspects of the health status of aquatic ecosystems.

MOTS CLÉS

Approche multiscalaire, Evaluation, Hydrosystème, One Health, Santé Ecologique

Assessment, Ecological health, Hydrosystem, Multiscale approach, One Health

1 UNDERSTANDING THE CHALLENGES OF WATER BODIES ASSESSMENT

1.1 Which method for an overall assessment?

Several methods are currently used to assess the ecological state of aquatic ecosystems. The Water Framework Directive (European Commission, 2000) mandates the assessment of all water categories, based on the monitoring of extended sites networks. The data collected constitute the base of the research conducted on aquatic ecosystems and has led to the development of reliable indicators for assessing water quality. These methods, focused on the water channel itself, are essential for the preservation and management of national water bodies. However, there is an increasing need for new methods that include an overall assessment of aquatic ecosystems. The development of systemic methods is crucial to meet the stakes of European regulations, such as restoration strategies, implement interdisciplinary management actions, or biodiversity policies.

The 'One Health' concept is one of the new themes demanding an overall assessment of ecosystems. Introduced in the 2000s, it promotes a linked vision of research and action concerning human, animal, and environmental health. A review of existing methods and key findings on ecosystem health reveals that this concept is increasingly studied by the scientific community. The assessment of 'ecosystem health' can help predict the functional levels needed to maintain a stable ecosystem or its resilience to external pressures (Giraudoux, 2022). For water bodies, health conditions depend not only on water quality but also on biodiversity, spatial organization within and around the aquatic ecosystem and the relationship with other environments (Delzon *et al*, 2013).

The Mental'Eau project aims to evaluate the link between human well-being and the ecological functions of aquatic ecosystems. The initiative involves a multidisciplinary team, combining expertise in natural sciences, social sciences, and scientific mediation. The research project, funded by the Rhin-Meuse Water Agency, is structured into two interconnected components: one focused on the ecological study of aquatic ecosystems and the other on the social dynamics of their visitors. The environmental component, detailed here, aims to explore the notion of ecosystem health and deliver reliable ecological data to support the sociological analysis.

1.2 The assessment method principles

The outcome of the ecological exploratory research is an overall assessment method of ecosystem health that incorporates criteria such as naturalness, structure, diversity, water quality and ecological value. The method is applied on a sample of 36 ecosystems (rivers, lakes, and canals) to assess the health of a wide range of aquatic ecosystems. These sites have both ecological interest and leisure or touristic stakes with a specific frequentation.

The principle of this method is to evaluate metrics at three different scales including a large diversity of parameters. This approach integrates complex environmental processes that cannot be captured by monitoring programs focused only on water quality or aquatic environments *sensu stricto*, i.e. riparian zones or ecological corridors of the close landscape.

2 APPROACHES TO EVALUATE THE HEALTH OF AQUATIC ECOSYSTEMS

1.3 Study area

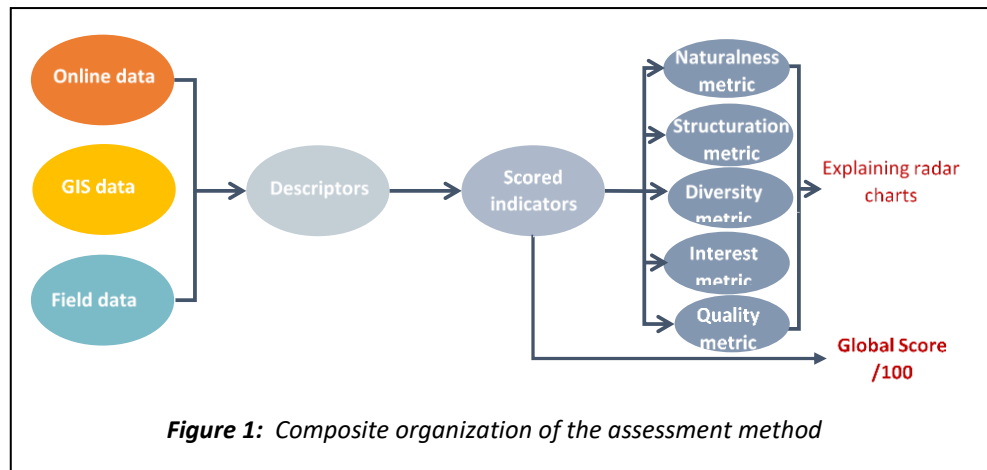
The method is designed to be applied to a wide variety of ecosystem types: rivers, lakes, artificial water bodies, and canals. Each of these aquatic environment types exhibits unique characteristics in terms of hydrological dynamics, biodiversity, and anthropogenic pressures. By incorporating this diversity of aquatic environments into the study, the objective is to develop a methodology relevant and applicable on a wide range of environmental contexts while providing a consistent and comparable assessment of health status.

1.4 Data collection

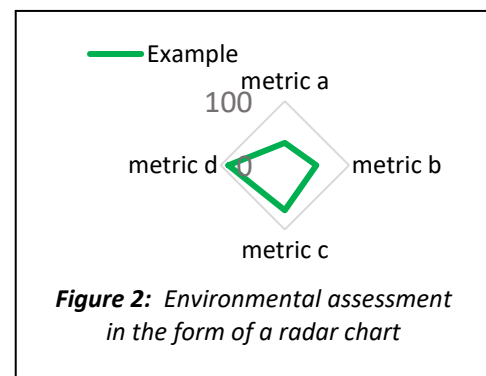
According to the Water Framework Directive, the ecological status of a water body is determined using biological, hydromorphological, and physico-chemical quality criteria assessed through specific indicators. The method relies on such data, complemented with information on pressures and biodiversity in the areas surrounding the aquatic ecosystems. These data are extracted from online platforms such as the Rhin-Meuse Water Agency's data portal (<https://rhin-meuse.eaufrance.fr>), processed using GIS tools, or collected by field observations.

1.5 Analytical methods

According to Levrel (2007), composite tools, that incorporate multiple descriptors, offer a more comprehensive approach and provide a less simplistic representation of the ecological phenomena being studied. Therefore, the method is organized into a series of metrics, defined as broad categories in which various indicators are calculated from descriptors.



The calculation of the indicators generates an overall health score, which can be explained in detail through radar charts that illustrate to what extent each metric contributes to the global health score.



2 RESULTS: AN INTEGRATIVE FRAMEWORK ASSESSMENT METHOD

2.1 Formal Framework of the developed method

The approach selected for this method is both multimetric and multiscale, addressing three levels of environmental processes to provide a health assessment that is consistent with ecological theory. This multiscale and multicriteria approach offers a comprehensive analysis, supported by a level of detail adapted to the needs of the eco-sociological study in the Mental'Eau project.

2.2 A multiscale approach for a systemic assessment

The metrics are calculated across three linked scales to integrate the connections of ecosystem processes in the evaluation and to meet the perception of individuals visiting the sites. The scales used in the assessment tool are the following:

- The landscape and broader territory
- The close surroundings of the site
- The aquatic environment itself

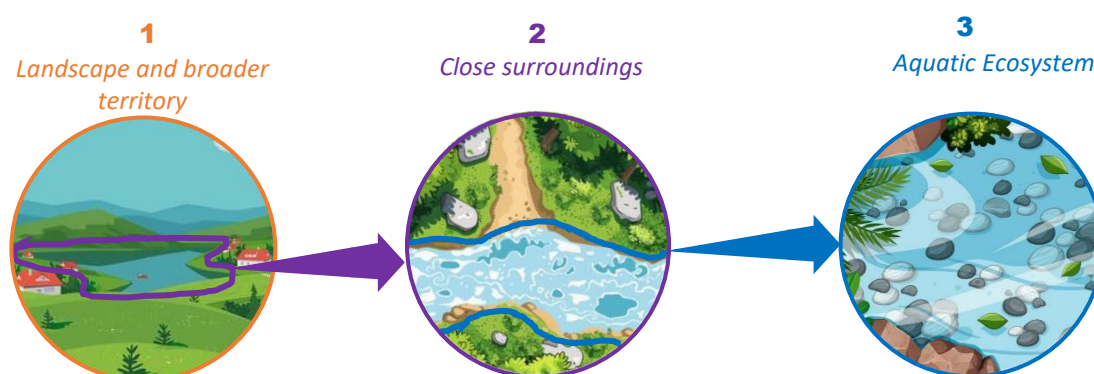


Figure 3: Spatial organization of the environmental assessment method

2.3 Integrating multiple criteria for a global evaluation

To ensure ecological coherence when assessing ecosystems of varying types, the adopted method is multimetric, integrating diverse criteria for ecosystem health. These metrics are constructed using a set of indicators based on physico-chemical, ecological or structural descriptors. The metrics selected are the following:

- **Naturalness:** Assesses human-induced alterations.
- **Structuring:** Evaluates the spatial organization.
- **Diversity:** Measures the supporting functions (habitats) and hosting functions (biodiversity).
- **Ecological Interest:** Assesses the heritage value (conservation, protection, and inventories).
- **Quality:** Evaluates the physico-chemical, biological, and ecological characteristics of the ecosystem.

In conclusion, the integrative method for the global evaluation of aquatic ecosystem health presented here is a tool that combines data on water quality, landscape organization, anthropogenic alterations, and surrounding biodiversity. It provides a straightforward evaluation fitted for environmental studies aiming an overall view of *ecosystem health*.

The other component of the Mental'Eau project, focusing on the social dynamics of the aquatic ecosystem's visitors is presented separately during the seminar (Denechaud *et al.*).

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